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A Study on the Effect of Hybrid Fiber Reinforced Fly Ash Concrete With Polypropylene Fiber and Glass Fiber

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ABSTRACT

Concrete is a weak building material in tension. Inherently, micro cracks will be present in concrete. The formation of micro cracks normally due to shrinkage of concrete. Fibers act as bridge towards crack propagation and increase the energy absorption capacity of the concrete. Moreover, concrete suffers from low tensile strength, limited ductility and little resistance to cracking. In order to improve these properties, an attempt has been made to study the effect of addition of polypropylene, glass fibers in ordinary Portland cement concrete along the cement replacement with flyash. In this study, the scope of research will be focused on the effect of hybrid fibers on mechanical properties. In present investigation is mainly focused on the effect of mechanical properties on M 30 grade of concrete by providing polyproplyene, glass fibers. Two different fibers will be used with different dosage levels by volume of concrete along with flyash.

INTRODUCTION

As a widely used structural material, the material properties of concrete are critical toward determination of structural ductility and reliability. Despite its popularity in large scale structures, concrete suffers material limitations; specifically with respect to its inability to carry moderate tension forces as experienced in flexural or direct tension loading. In compression loading, the maximum capacity and subsequent ductility can only be reached upon the addition of confining stress, commonly applied through reinforcing steel stirrups/spirals. To improve the intrinsic properties of concrete with respect to both tension loading and element ductility, fibers can be introduced into the mixing process. Introduction of fibers into the cement matrix provides additional energy absorption mechanisms to delay crack growth and element failure.Fibers

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present in the fracture process zone ahead of the crack tip can subdue and delay crack propagation, while fibers incorporated in the crack wake provide a load transfer path to maintain load carrying capacity and restrict crack growth. The addition of multiscale fiber reinforcement optimizes fiber-crack interactions through the process of delaying macrocrack formation and providing post cracking ductility. The concept of multi scale fiber incorporation in concrete has started with **Rossi** and described in with studies focused on steel fiber and multi type fiber additions respectively. The mix developed and described by **Blunt and Ostertag** and advanced in this study incorporating both steel and polyvinyl alcohol (PVA) fiber types shall hereafter be referred to as Hybrid Fiber-Reinforced Concrete (HyFRC). The steel fibers include two discrete hooked end fibers of differing lengths and aspect ratios for the purpose of macrocrack interactions, while a single type straight PVA microfiber was used to stabilize microcracks. Fiber hybridization incorporating a low volume fraction of PVA fibers has been shown experimentally in to produce measurable improvements to composite strength in relation to fiber reinforced cementitious composites comprising solely macrofibers. While the improved toughness property of fiber reinforced concrete is typically in direct relation to the included fiber content, the feasibility of high fiber volume inclusion has not been realized in a conventional concrete matrix. The reasons for this lie in the mixing and placement procedures for concrete which require workability, subjectively measured as an ability to adequately disperse all components and consolidate into formwork. Conventional fiber reinforced mix designs limit the allowable fiber content to less than two percent by volume, but even under these restrictions supplementary materials may be required to aid in the mixing process and extra care must be given to ensure satisfactory consolidation during placement.

Fiber-Reinforced Cementitious Composites (FRCCs), obtained by mixing short fibers within conventional cement-based matrices (i.e., mortar or concrete), can be considered as structural materials featuring both post-cracking tensile strength higher than the corresponding matrices and enhanced toughness (in terms of absorbed strain energy) due to the bridging actions developed by fibers across the opening crack surfaces. Among these materials, Fiber-Reinforced Concrete (FRC) is commonly used for structural purposes, such as strengthening existing members and controlling crack opening in new ones.

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LITERATURE REVIEW:

Antonio discussed the results of experimental tests performed on concrete specimens internally reinforced with polypropylene and steel fibers. Specifically, samples of five mixtures (plus a reference plain concrete), characterized by the same total volume of fibers, but different fractions of polypropylene and steel fibers, were tested under compression and in bending. This study was aimed to clarify the influence of different combinations of these fibers on the resulting fracture behavior of Hybrid Fiber-Reinforced Concrete (HyFRC). On the one hand, FRC specimens made of only polypropylene fibers exhibited an excellent post-cracking toughness for the small crack opening ranges of relevance for the Serviceability Limit State, while an apparent decay was observed in terms of post-cracking response, especially at wide crack openings. On the other hand, a marked re-hardening response was observed in the post-cracking behaviour for specimens with higher percentage of steel fibers; however, at the same time, the corresponding results showed a relevant scatter. **Shaikh** investigated the Strain hardening and multiple cracking behavior of hybrid fiber reinforced cement composites containing different hybrid combinations of steel and polyethylene (PE) fibers under four-point bending are reported. The total volume fraction of fibers was kept constant at 2.5% to maintain a workable mix. Generally, the steel–PE hybrid composites exhibited lower flexural strength but higher deflection capacity than steel–PVA hybrid composites. The rate of strength loss after peak load in steel–PE hybrid composites was found low compared to steel–PVA hybrid system. The 50% replacement of cement by fly ash is found to be an optimum fly ash content in hybrid fiber composites. **Jing Jun** investigated the effect of high performance polypropylene (HPP) fiber on the mechanical properties of lightweight aggregate concrete (LWC). The mechanical properties include the compressive strength, splitting tensile strength, flexural strength, flexural toughness and the impact resistance. Two types of interfacial transition zone (ITZ) at aggregates/cement paste and fibers/cement paste were investigated by using Scanning Electron Microscope (SEM). The experimental results showed that the addition of HPP fibers in LWC could significantly improve its mechanical properties Due to better bond property between aggregates and cement paste than that between fibers and cement paste, the aggregate-paste interface is not the weakest link in LWC. When the addition of HPP fibers is increased beyond 9 kg/m3 (0.95% Vol.), the dispersion of fibers

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becomes very difficult. Based on various mechanical strengths, to enhance the mechanical properties of concrete, the optimal fiber content of 9 kg/m3 (0.95% Vol.) is recommended. Cengiz reported the comprehensive study on the properties of concrete containing fly ash and steel fibers. Properties studied include unit weight and workability of fresh concrete, and compressive strength, flexural tensile strength, splitting tensile strength, elasticity modulus, sorptivity coefficient, drying shrinkage and freeze–thaw resistance of hardened concrete. Fly ash content used was 0%, 15% and 30% in mass basis, and fiber volume fraction was 0%, 0.25%, 0.5%, 1.0% and 1.5% in volume basis. The laboratory results showed that steel fiber addition, either into Portland cement concrete or fly ash concrete, improve the tensile strength properties, drying shrinkage and freeze–thaw resistance. However, it reduced workability and increase sorptivity coefficient. Although fly ash replacement reduce strength properties, it improves workability, reduces drying shrinkage and increases freeze–thaw resistance of steel fiber reinforced concrete. The performed experiments show that the behaviour of fly ash concrete is similar to that of Portland cement concrete when fly ash is added.

3.0 MATERIALS

3.1 Cement:

Ordinary Portland cement of 53 grade, conforming to IS: 12269-1999 with particle size of 90µ has been used in the present investigation. The specific gravity, standard consistency were 3.12 and 32% respectively.

3.2 Fine Aggregates:

Locally available river sand conforming to Zone-II as per IS: 383-1999 has been used. The bulk density, specific gravity, and fineness modulus of the sand were 1.41g/cc, 2.68, and 2.9.

3.3 Coarse Aggregates:

Crushed granite aggregate of maximum 16 mm size conforming to IS: 383-1999 has been used. The bulk density, specific gravity and fineness modulus of the coarse aggregate were 1.46g/cc, 2.7 and 7.1.

3.4 Fly ash:

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Fly ash of Class F conforming to IS: 3812: Part-II-2003 obtained from Ramagundam thermal power plant (India) with a specific gravity of 2.18 and fineness of 6422 cm^2/gm was used.

3.5 Glass Fibers:

Glass fiber of 6 mm length and tensile strength 1700 MPa were used. Aspect ratio of glass fibers was 428.57.

3.6 Polypropylene Fibers:

Tensile strength of polypropylene fibers were 350 $N/mm^{2,}$ with an aspect ratio of 545.

3.7 Water:

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about $3/10^{th}$ of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers.

4.0 EXPERIMENTAL PROGRAM:

The investigation was aimed at studying the effect of glass fibers and polypropylene fibers on the standard specimens. Compressive strength and split tensile will be evaluated in this study on M30 concrete. Mix proportioning of concrete will be done based on guidelines of IS 10262: 2009. To study effect on strength of concrete the specimens will be tested for 28 days of curing. Standard cubes (150x150x150 mm) will be cast to investigate the behaviour on mechanical properties. Slump and Compaction factor will be done to test the effect on workability of concrete due to hybrid fibers. The inclusion of glass fibers will be varied from 0 to 0.009% with an increment of 0.03% i.e 0, 0.06%, 0.09% by volume of concrete. The inclusion of polypropylene fibers will be varied from 0 to 0.2% with a variation of 0, 0.1%, and 0.2% by volume of concrete. The replacement of cement with flyash will be done by 30% by weight of cement.

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Table 1 - Mix Proportions of mixes M 30 grade in kg/m^3

Cement	Fine Aggregate	Coarse Aggregate	Water
450	812	1080	175

5. RESULTS AND DISCUSSION

5.1 Workability:

Workability test is performed on the fresh concrete by slump cone and compaction factor test. Slump cone test and compaction factor were conducted as per Indian standards as explained in previous chapter. The results of slump cone and compaction factor test for M30 grade of concrete with glass fibers are shown in table 2.

Table 2 – Slump and compactor factor test values of concrete with glass and polypropylene fibers

Dosage of Glass and polypropylene fibers (%)	Slump (mm)	Compaction Factor Test
0	112	0.95
GF(0.06)+PF(0.1)	94	0.94
GF(0.06)+PF(0.2)	86	0.91
GF(0.09)+PF(0.1)	78	0.89
GF(0.09)+PF(0.2)	69	0.87

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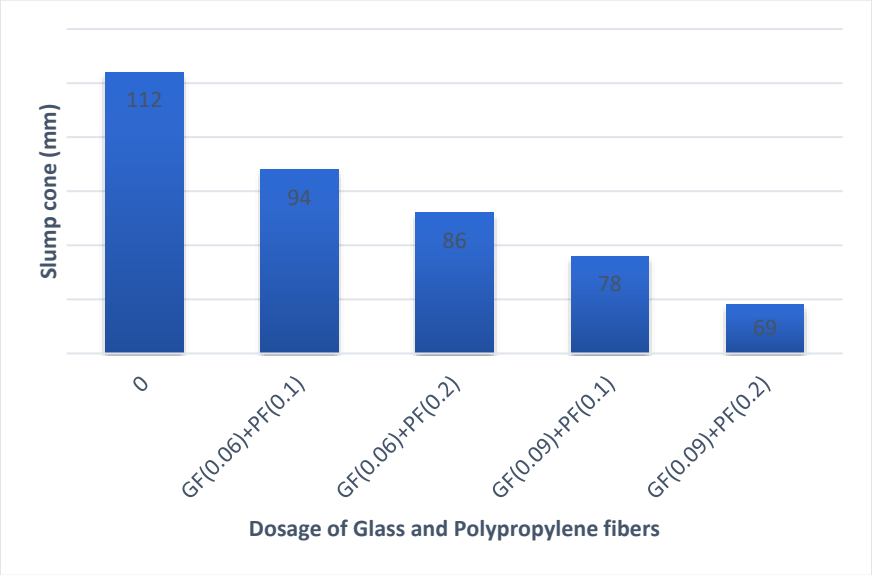


Figure 1: Effect of glass and polypropylene fibers on workability of concrete

5.2 Mechanical Properties:

Compression testing machine of 2000 kNhas been used for the test of compressive strength. The results of compressive strength are given in the Table 3.

Table 3 – Mechanical properties of M30 grade of concrete with glass and polypropylene fibers

Dosage of Glass and polypropylene fibers (%)	Compressive Strength (MPa)	Split tensile Strength (MPa)	Flexural Strength (MPa)
0	38.2	2.89	4.45
GF(0.06)+PF(0.1)	40.2	2.96	4.57
GF(0.06)+PF(0.2)	42.4	3.04	4.69
GF(0.09)+PF(0.1)	46.5	3.18	4.91
GF(0.09)+PF(0.2)	43.3	3.07	4.74

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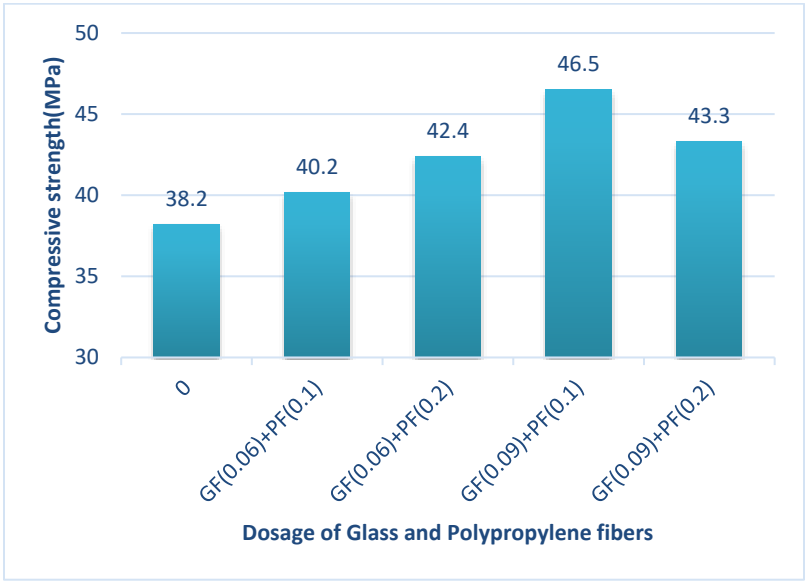


Figure 2: Effect of glass and polypropylene fibers on Compressive strength

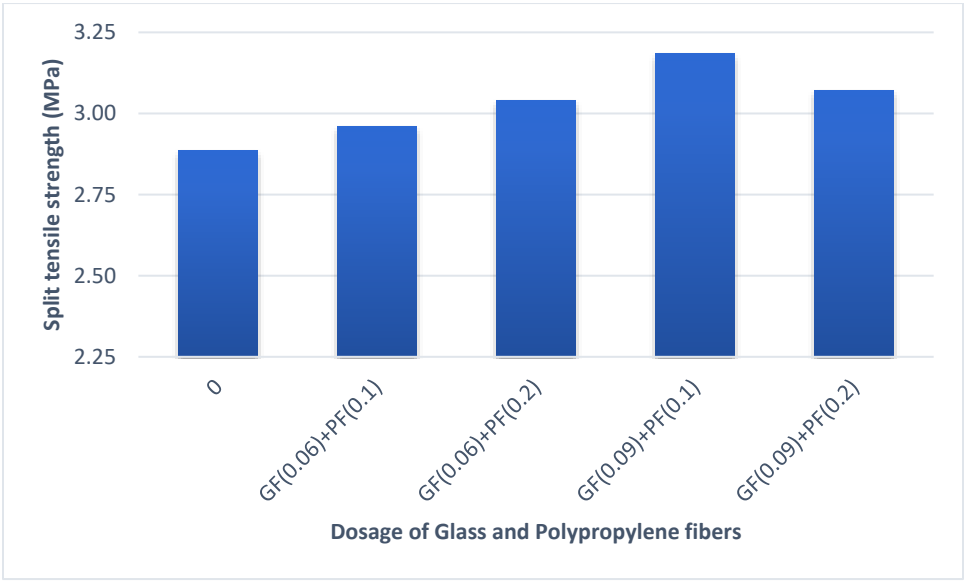


Figure 3: Effect of glass and polypropylene fibers on Split tensile strength

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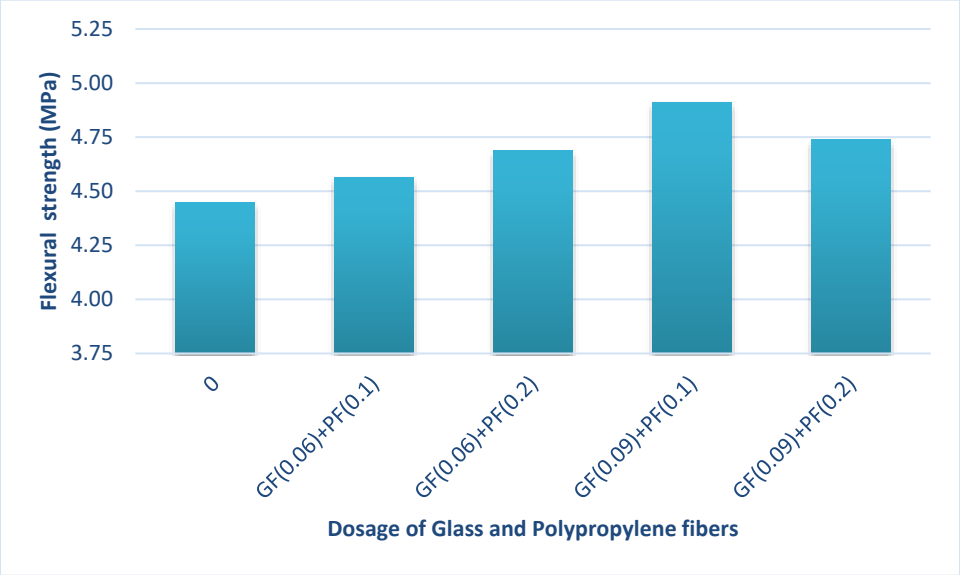


Figure 3: Effect of glass and polypropylene fibers on Flexural strength

6.0 CONCLUSIONS:

1. Compressive strength of concrete increased with the increase in percentage of glass and polypropylene fibers.
2. Inclusion of fibers effected the workability of concrete, the max dosage of glass (0.09%) and polypropylene (0.2%) fibers adversely effected the slump value of concrete.
3. Compressive strength has marginally increased with inclusion both fibers in all dosages.
4. The effect of hybrid fibers is seen significantly in tensile properties (Split tensile and Flexural strength) of concrete.
5. The failure pattern of has been changed from brittle nature to ductile with the addition of hybrid fibers.

REFERENCES

1. Zollo RF. Fiber-reinforced concrete: an overview after 30 years of development. Cement Concrete Comp 1997; 19:107–22.
2. Topcu IB, Canbaz M. Effect of different fibers on the mechanical properties of concrete containing fly ash. Constr Build Mater 2007; 21:1486–91.

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ISSN: 0971-1260
Vol-22-Issue-4-October-December-2019

3. Qian CX, Stroeven P. Development of hybrid polypropylene-steel fiber-reinforced concrete. Cement Concrete Res 2000; 30:63–9.
4. Gutierrez RM, Diaz LN, Delvasto S. Effect of pozzolans on the performance of fiber-reinforced mortars. Cement Concrete Comp 2005; 27:593–8.
5. Eren O, Celik T. Effect of silica fume and steel fibers on some properties of high-strength concrete. Construction Build Materials 1997; 11:373–82.
6. Ahmed SFH, Maalej M, Paramasivam P. Flexural responses of hybrid steel-polyethylene fiber reinforced cement composites containing high volume fly ash. Constr Build Mater 2007; 21:1088–97.
7. Siddique R. Properties of concrete incorporating high volumes of class F fly ash and san fibers. Cement Concrete Res 2004; 34:37–42.
8. Mohammadi Y, Singh SP, Kaushik SK. Properties of steel fibrous concrete containing mixed fibers in fresh and hardened state. Constr Build Mater, in press, doi:10.1016/j.conbuildmat.2006.12.004.
9. Yazıcı S, Inan G, Tabak V. Effect of aspect ratio and volume fraction of steel fiber on the mechanical properties of SFRC. Constr Build Mater 2007; 21:1250–3.

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